I. C. 7503 May 1949

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

INFORMATION CIRCULAR

SAFEGUARDING UNDERGROUND WORKMEN FROM NOXIOUS GASES RESULTING FROM BLASTING IN STRIP MINES

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BY

E. H. McCLEARY, M. W. PRICE, AND JOSEPH V. MATHER

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SAFEGUARDING UNDERGROUND WORKMEN FROM NOXIOUS GASES RESULTING FROM BLASTING IN STRIP MINES[1]

By E. H. McCleary[2], M. W. Price[3], and Joseph V. Mather[4]

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7503."

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INTRODUCTION

The asphyxiation or poisoning of workmen in underground mines by noxious gases from blasting in adjacent strip mines can be prevented.

Considerable progress has been made in eliminating or reducing hazards to the health and safety of underground workmen in anthracite mines, but seldom does a year pass without reported cases of underground workmen being poisoned by the fumes from blasts of explosives in strip-mining operations. In the early days of the anthracite industry, the coal near the surface was only partly mined, and many small stumps of pillars and barrier pillars were left standing; these pillars are now being recovered by stripping. It has become necessary to give more consideration to the effects of blasting at strip mines upon the quality of the air in underground mines adjacent to stripping operations.

Special precautions are taken by the personnel of the Jeddo-Highland Coal Co., whose mines are near Jeddo, Luzerne County, and near Centralia in Columbia and Schuylkill Counties in the anthracite region of Pennsylvania, to prevent asphyxiation of workmen by carbon monoxide or other toxic gases resulting from blasting in strip mines. The procedures established by the Jeddo-Highland Coal Co. are given in this circular so that others may benefit thereby and thus avoid hazards to underground workmen where mining is carried on under similar circumstances.

ACKNOWLEDGMENTS

The authors express their gratitude to the officials and workmen of the Jeddo-Highland Coal Co. whose assistance made this information circular possible. Special acknowledgment is given C. A. Garner, vice president and general manager, and Wilmot C. Jones, general superintendent, who made much of the information herein available for publication.

HAZARDS TO UNDERGROUND MINE WORKMEN FROM STRIP-MINE BLASTING

The hazards of noxious gases from blasting at strip mines adjacent to underground mines are not understood fully by many mine officials. During the removal of coal in many strip mines, old chambers or breasts of former underground operations often are broken into, as shown in figures 1 and 2. In such instances, gases from blasting may be drawn into underground workings by the air currents therein or be driven into them by the force of the blasts.

Carbon monoxide usually is one of the gases produced by the detonation of high explosives, and it is the most hazardous to underground workmen, even when breathed in small quantities. The effects of carbon monoxide upon human beings is shown on the chart in figure 3.

Information Circular 7296[5] reports the effect upon underground workmen of carbon monoxide from strip-pit blasting substantially as follows:

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[5] Forbes, J. J., and Weaver, H. F., Blasting Hazards in Strip Mines Adjacent to Underground Workings: Bureau of Mines Inf. Circ. 7296, 1944, 5 pp.

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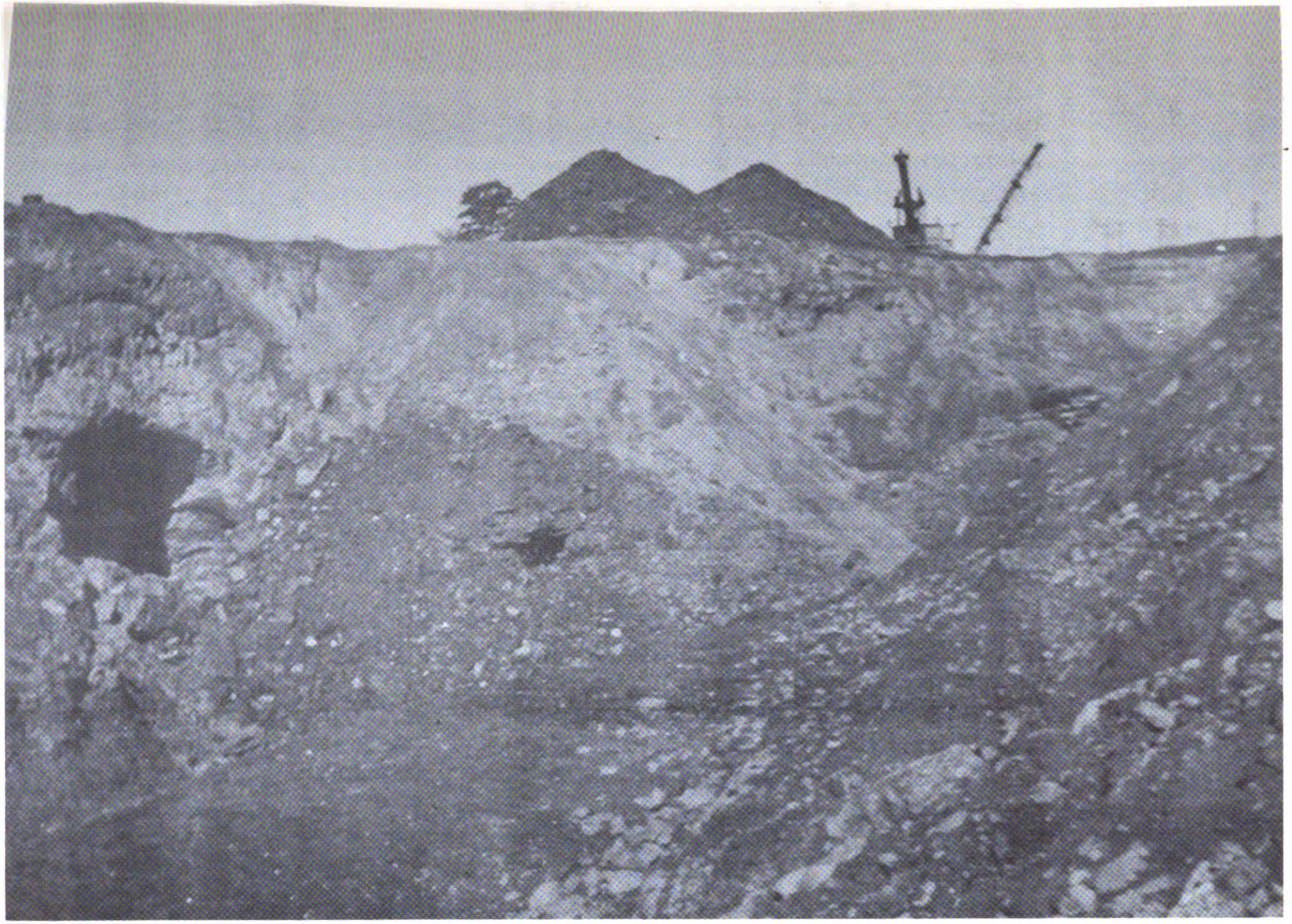

Figure I. - Old breast broken into during strip mining.

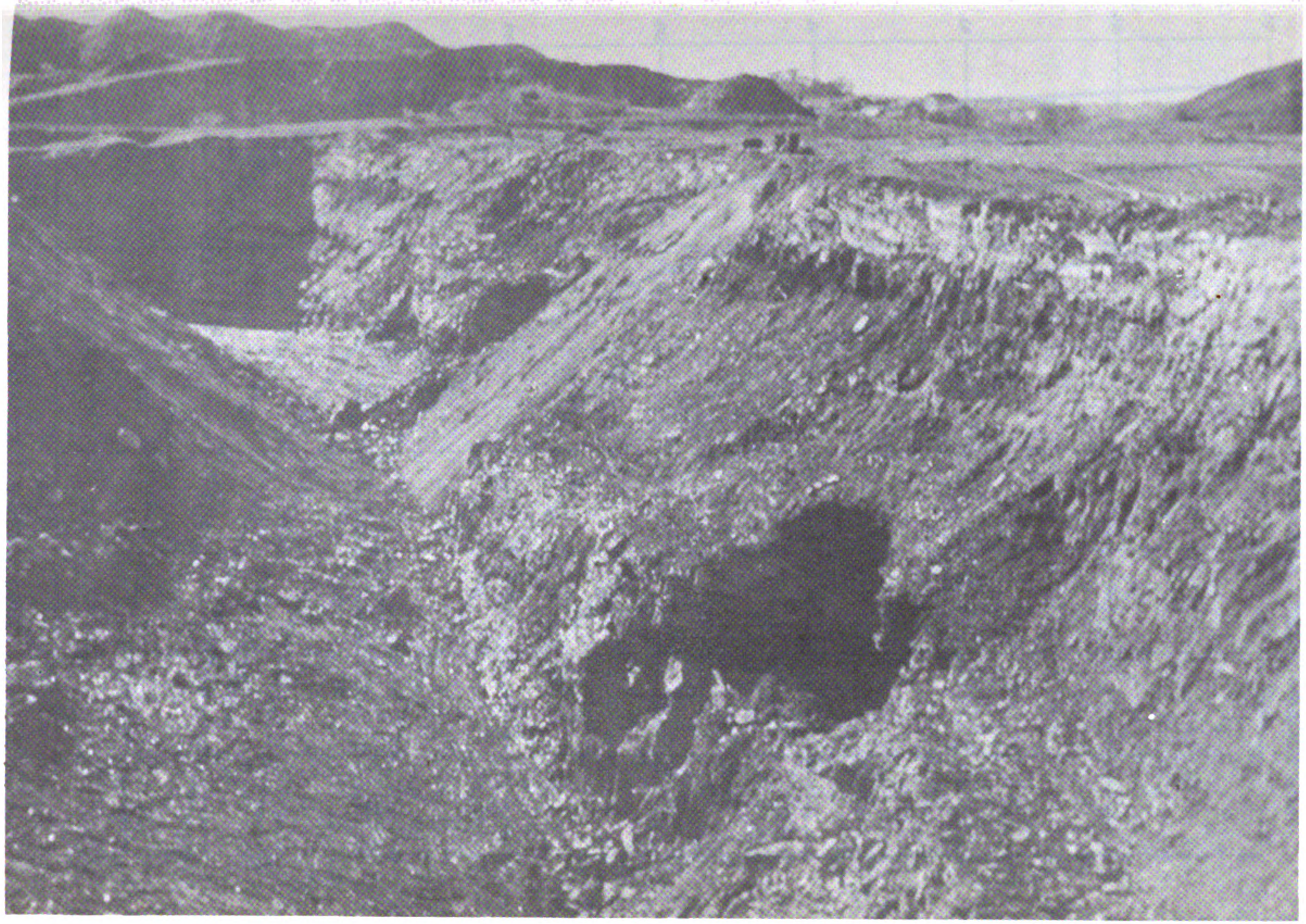

Figure 2. - Old chamber broken into at stripping operation.

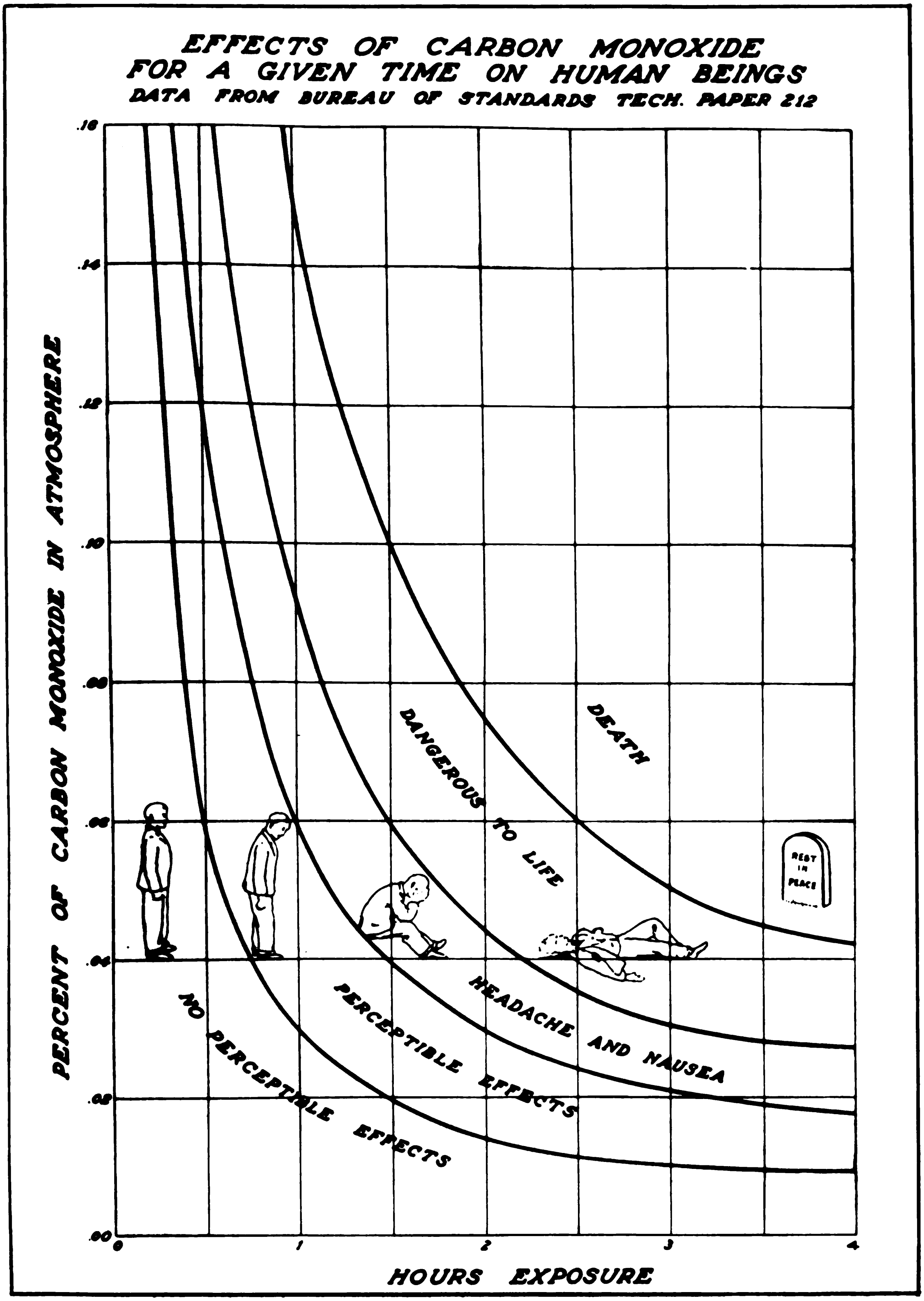

Figure 3. - Effects upon human beings of exposure to carbon monoxide.

MINE A

Sixty-Percent Dynamite Used for Blasting

Seventy-nine drill holes ranging in depth from 40 to 45 feet were charged with 21,000 pounds of 60-percent gelatin dynamite and fired. Forty minutes later, men working on the second level in an underground mine beneath the stripping operation were affected by carbon monoxide, and in about 3 hours men on the first level also were affected. One of the men, a veteran in mine rescue operations, suspecting that carbon monoxide might be present in the mine atmosphere, quickly rounded up the other 10 men in the mine and they withdrew to the surface, thereby avoiding serious consequences.

Air flow in the underground mine was induced by natural means; on the morning of the incident the intake was through openings connected with the strip mine, and the upcast or return was at the main slope.

The mine officials, realizing that the carbon monoxide originated in the stripping operation after the heavy blast, issued the following instructions to prevent a similar occurrence:

> The stripping foreman must report to the mine superintendent (who has charge of the surface and underground mines) before firing heavily loaded holes. Permission to fire must be obtained from the superintendent before such shots can be fired. The blasts must be fired on Sunday or on other days when the underground mine is idle.

MINE B

Liquid-Oxygen Explosive Used for Blasting

Twenty-eight workmen coming off shift from an underground mine were overcome by carbon monoxide. Some were affected seriously, but all recovered after prompt treatment in a nearby hospital.

The underground mine was opened by slopes, and the coal beds were badly folded. Part of the mine workings were underneath a surface stripping operation, which had been opened a few months earlier, but the officials of the underground mine were unaware of blasting in the strip mine. A prompt investigation, however, disclosed that 1-1/2 to 3 hours before the men became ill, 22 holes ranging in depth from 45 to 70 feet were charged with 5,700 pounds of liquid-oxygen explosive and fired.

Ventilation in the underground mine was by natural means. The temperature was variable, changing from warm in the morning to below freezing shortly after noon, and the barometric readings fluctuated from high in the morning to low at noon, resulting in reversal in the direction of air flow in the mine.

It was learned that some holes in the strip mine had been drilled into open chambers or into crevices that extended to the mine workings; many holes had to be blocked at the bottom to prevent the explosives from dropping into the underground workings.

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Carbon monoxide is a product of detonation of liquid-oxygen explosive, and tests of the mine atmosphere 4 hours after blasting disclosed dangerous concentrations of this poisonous gas. Unquestionably, the carbon monoxide came from the stripping operation.

After the incident in mine B, company officials issued instructions in part as follows:

(a) Blasting shall not be done in the open cut until the mine foreman personally notifies the open-cut foreman that no men are underground.

(b) Men will not be permitted underground after a blast on the surface until all working places and travelways have been inspected and the air therein is tested for and found free of carbon monoxide.

A third similar incident occurred recently at a colliery near Wilkes-Barre, Pa., when 15 underground workmen in the Top Ross vein became ill from fumes of a blast of about 11 tons of high explosives in a nearby strip mine.

Stripping operations were carried on at the outcrop of the Baltimore vein. A representative of the explosives manufacturer supervised charging of holes and firing of blasts. A total of 21,950 pounds of explosives was charged in 24 drill holes, which were 9 inches in diameter and averaged 75 feet in depth. The explosives used were gelatin and ammonia dynamites, 40-percent strength; 1,100 pounds was the maximum amount charged in a single hole.

Some of the air that ventilated the Top Ross vein section entered the mine through an abandoned slope and also through old chambers formerly driven to the outcrop. Pillars between the abandoned chambers were being recovered at the time of the blast. A total of 35,000 cubic feet of air a minute was entering the affected workings and, after passing through five working places, was conducted directly to the main return and the fan.

The superintendent was notified that a blast would be fired in the stripping operation at 2:45 p.m., and he notified the underground mine foreman. Six men working in the Baltimore vein in the same general area were removed because of the possibility that the blast might cause a fall of roof, but the men in the Top Ross section were permitted to remain in their places. The blast was fired promptly at 2:45 p.m. The mine foreman, who failed to hear the blast, called the strip mine office by telephone shortly after the appointed time and was informed that the blast had been fired.

At about 5 p.m., workmen in the Top Ross section began to complain of feeling ill. The mine foreman was notified, and he immediately ordered the men removed from the section. Eight men were sent to the hospital for observation, and the others were taken to their homes. It was not necessary to use respiratory protection in removing the men.

Additional ventilation was provided for the section, and the working places were found to be uncontaminated on the following morning by safety inspectors using carbon monoxide detectors.

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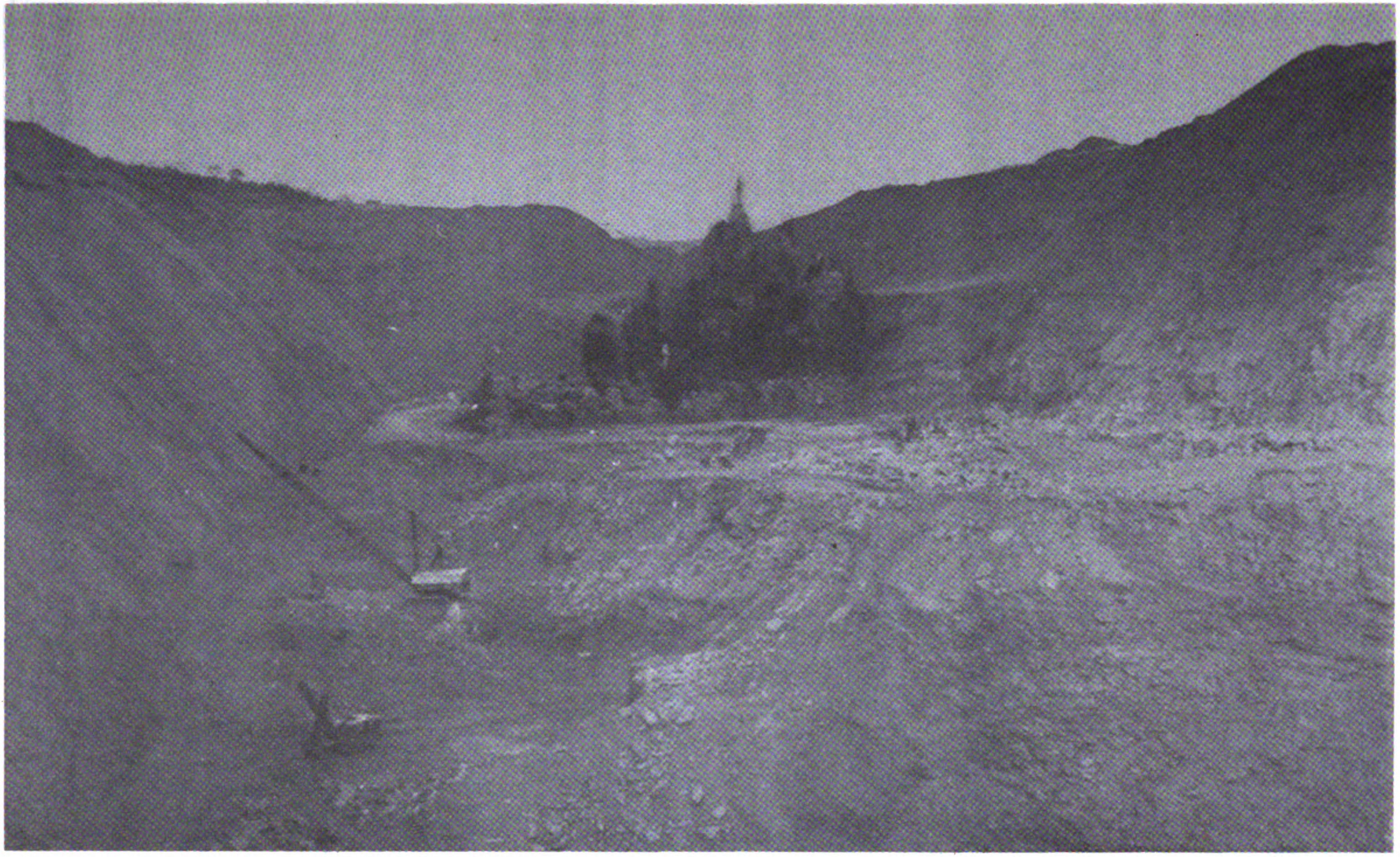

Figure 4. - A blast of 89,488 pounds of explosives placed in 304 blast holes to move 67,146 cubic yards of material.

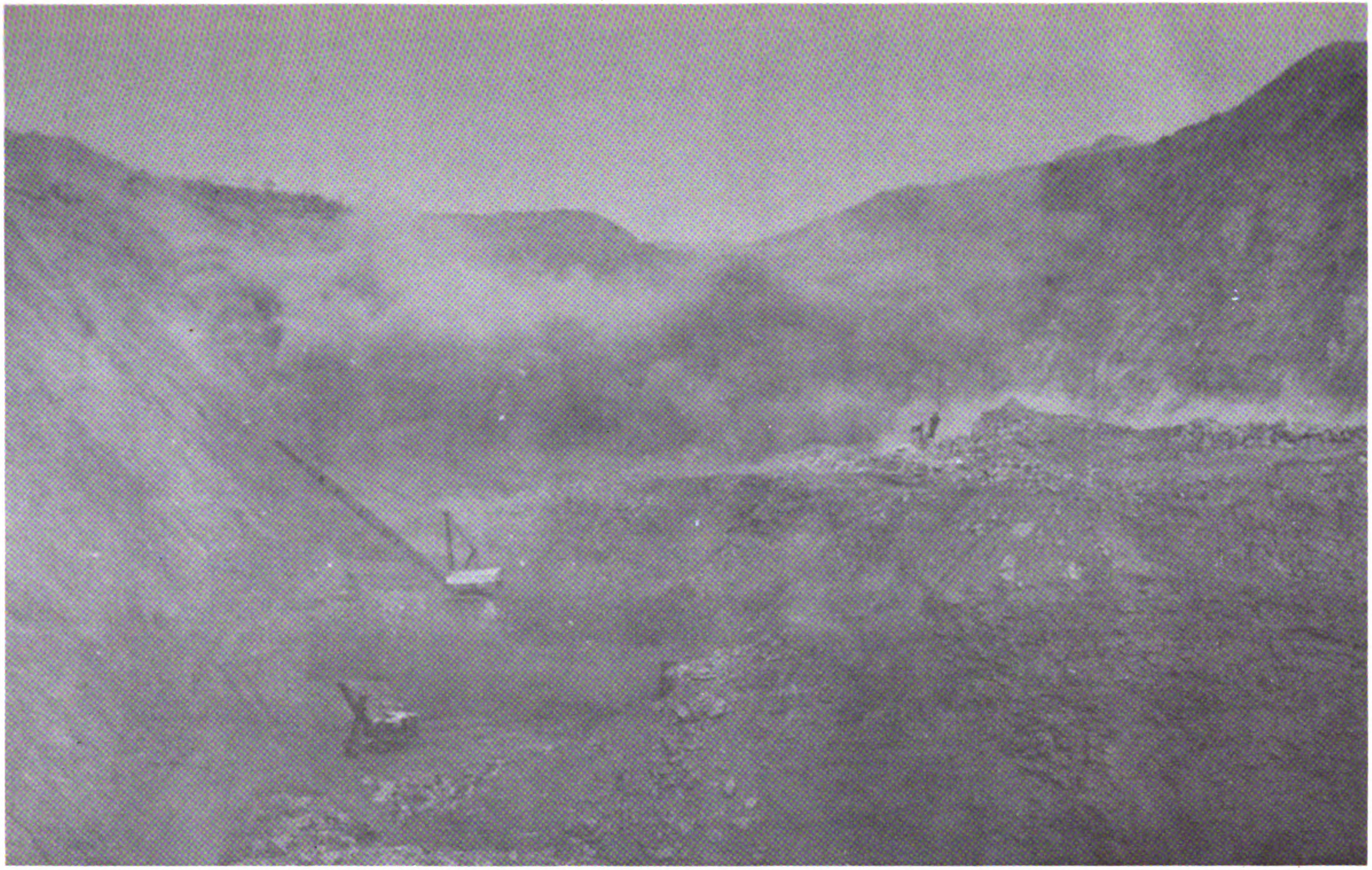

Figure 5. - Shows how the gases expanded and filled the pit after the blast shown in figure 4.

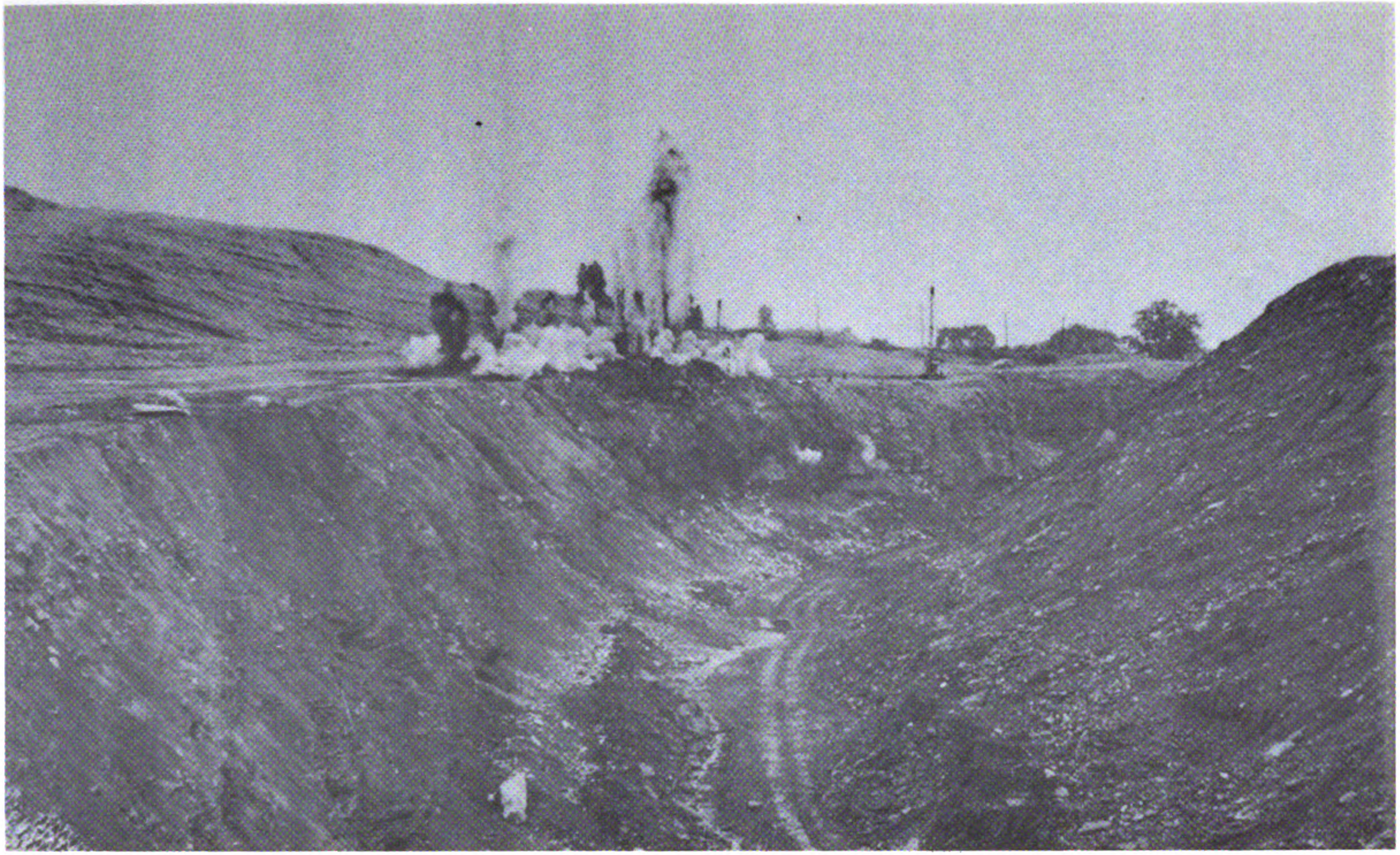

Figure 6. - 17,500 cubic yards of material being blasted with 9,088 pounds of explosives.

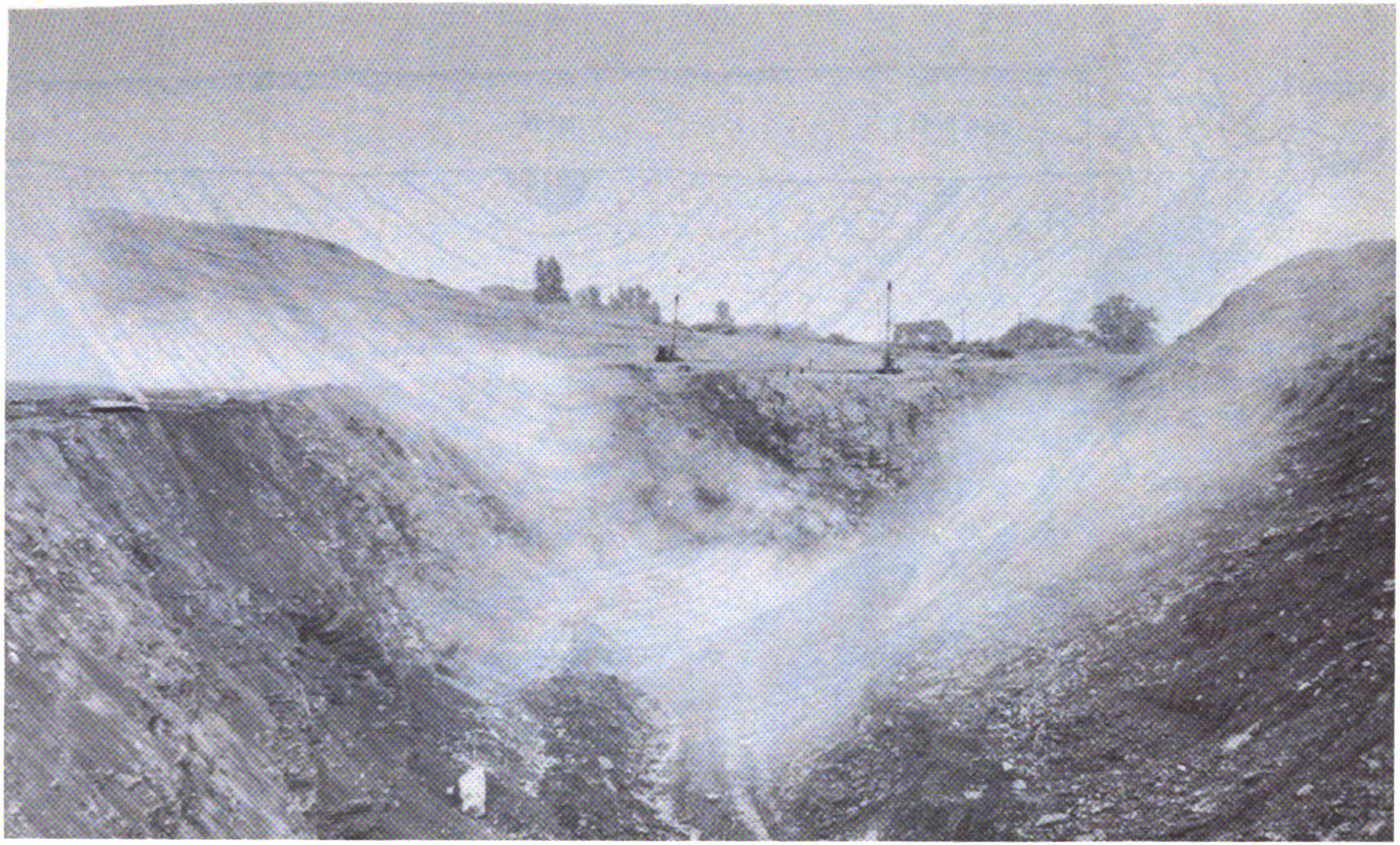

Figure 7. - Shows how the gases from the blast in figure 6 remained in the pit after the blast.

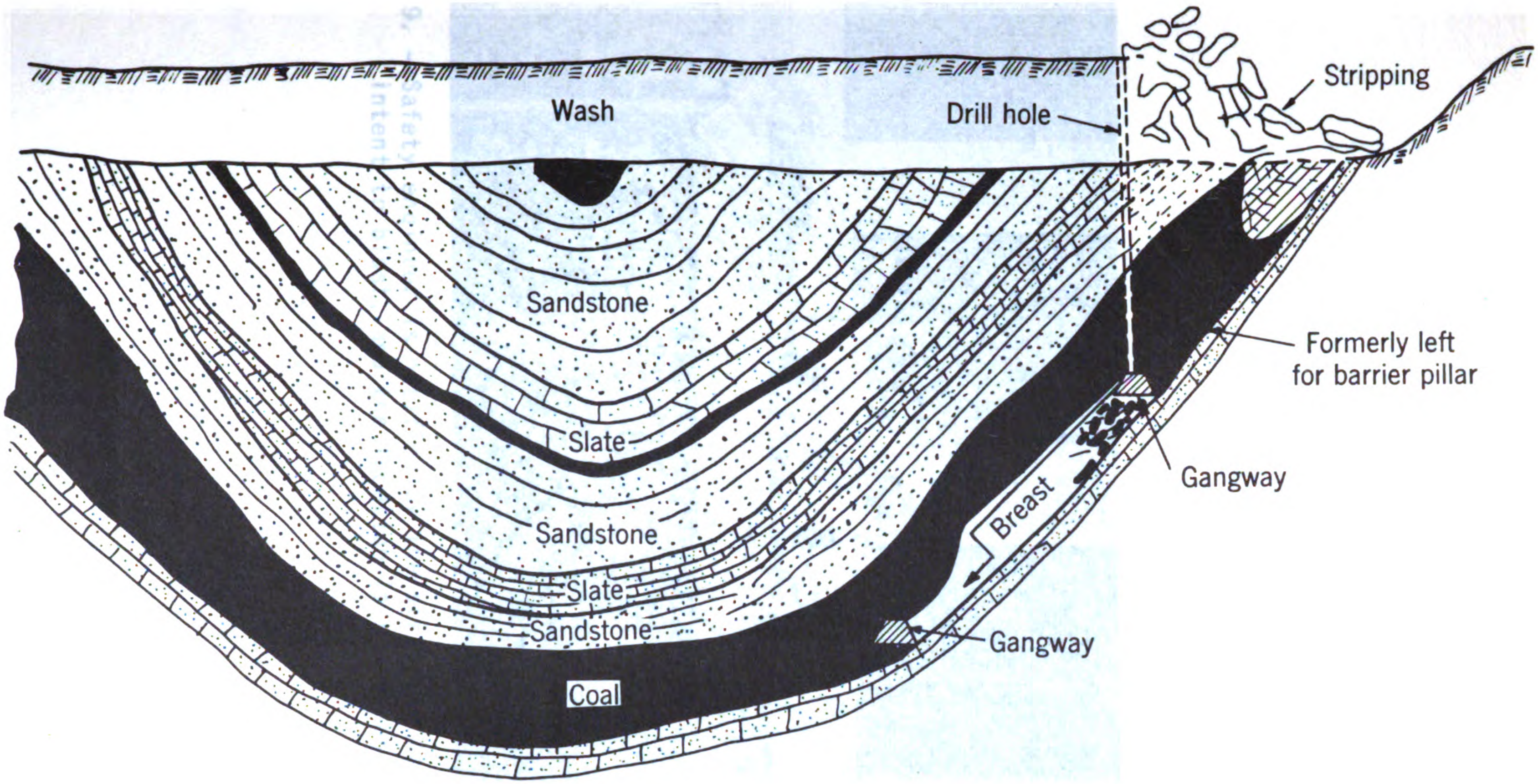

Figure 8. - Cross section of coal vein showing how gases are forced through crevices by violence of blast.

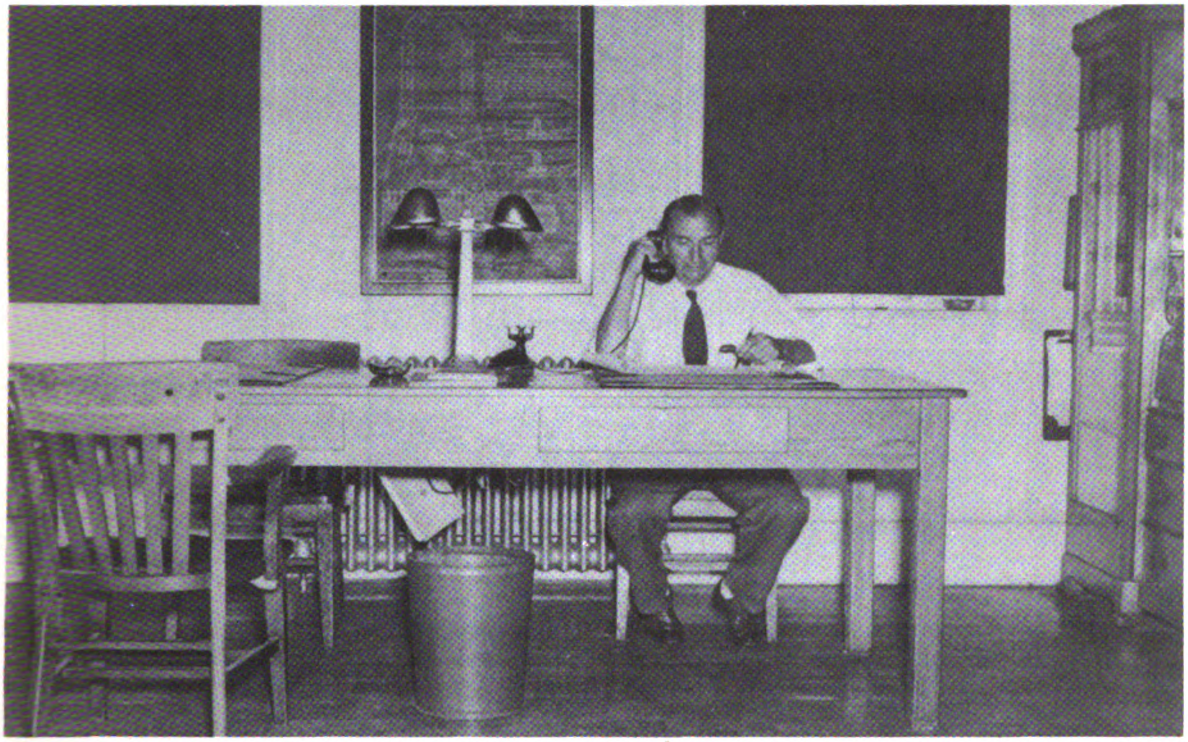

Figure 9. - Safety engineer is notified by the stripping contractor, of the intent to blast, and the location is posted on a map.

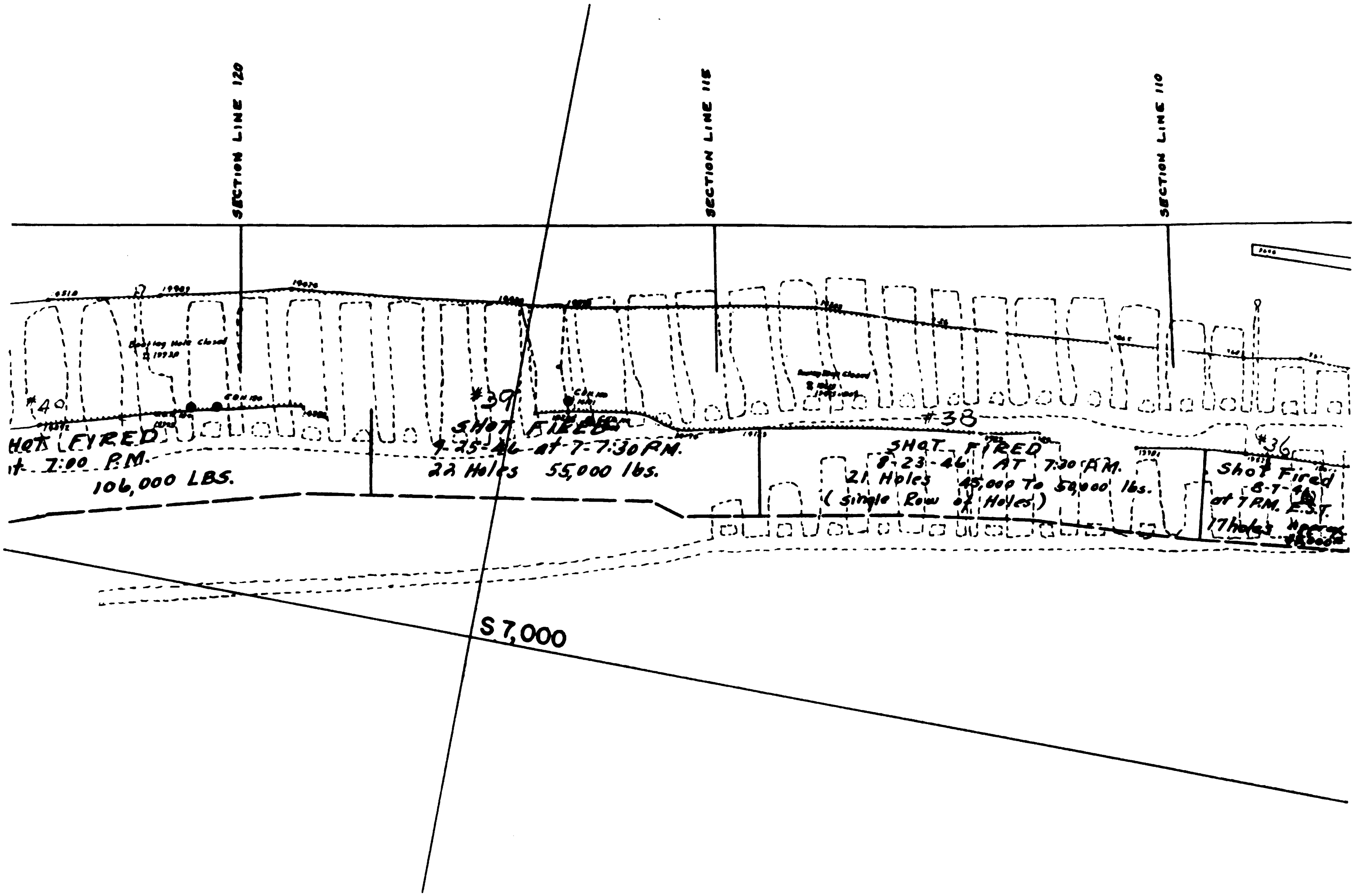

Figure 10. - Location, amount of explosives used, time of blast, and date are recorded on the surface mine map by the safety engineer.

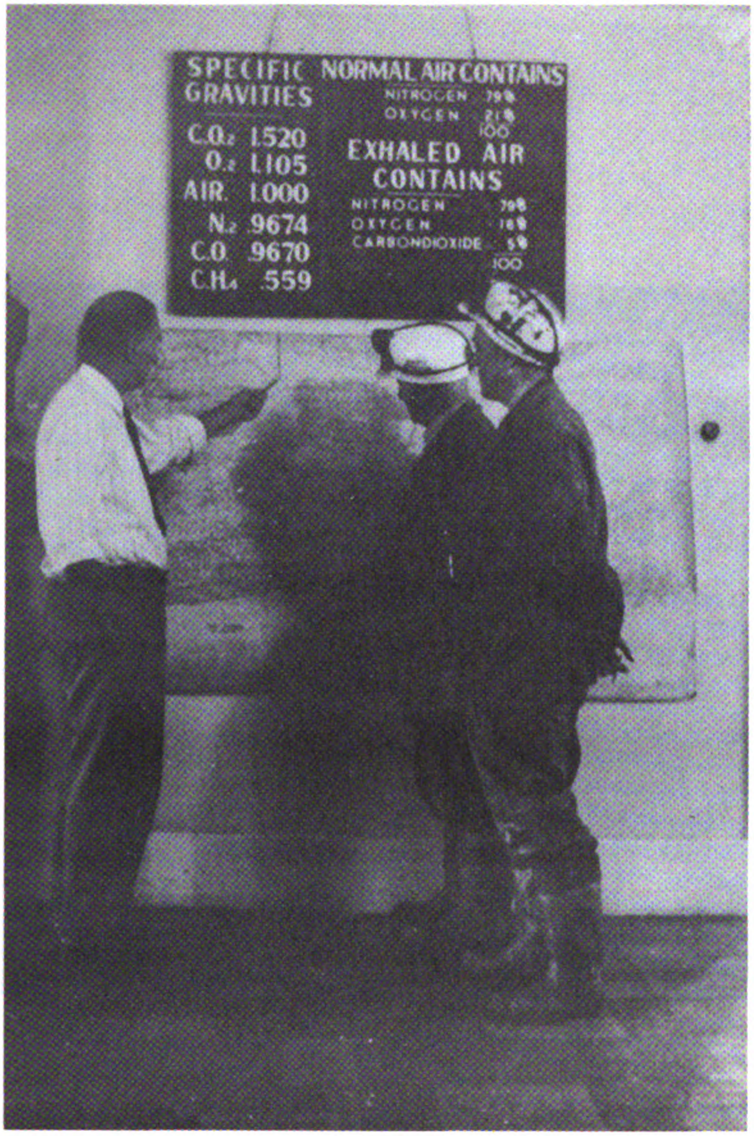

Figure 11. - After a study of the underground mine map (below the air chart) the safety inspectors are instructed to proceed to the underground mine.

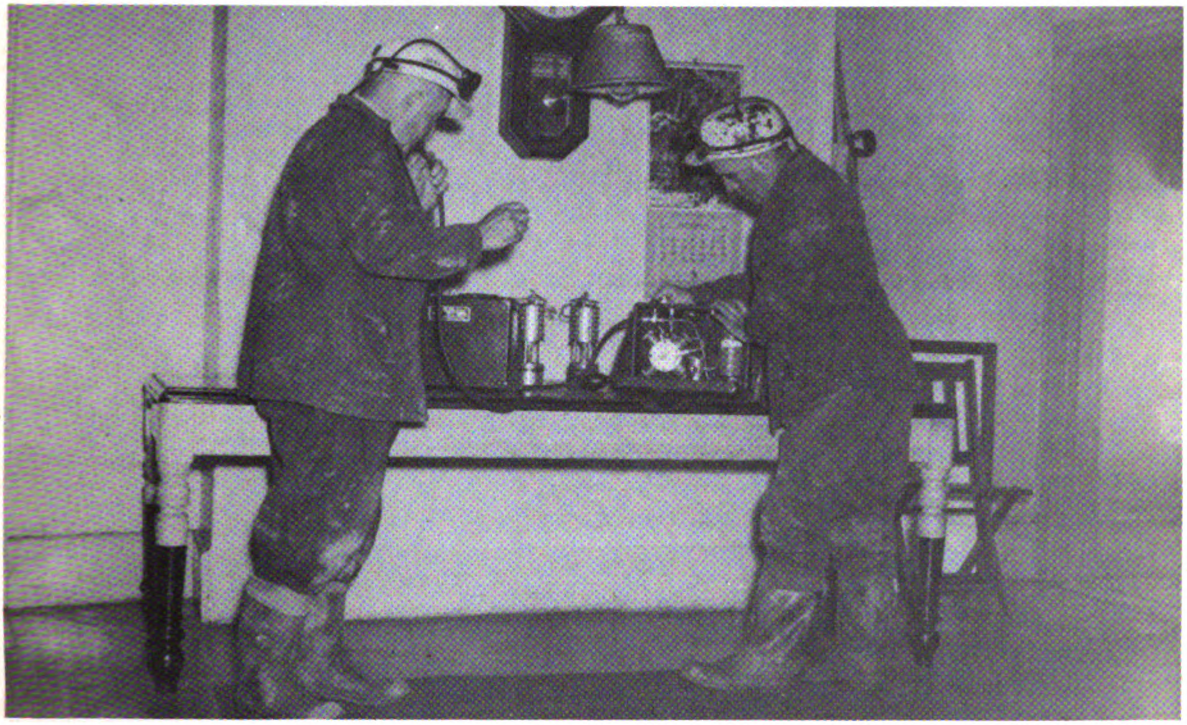

Figure 12. - Inspectors examine their equipment before proceeding to the underground mine.

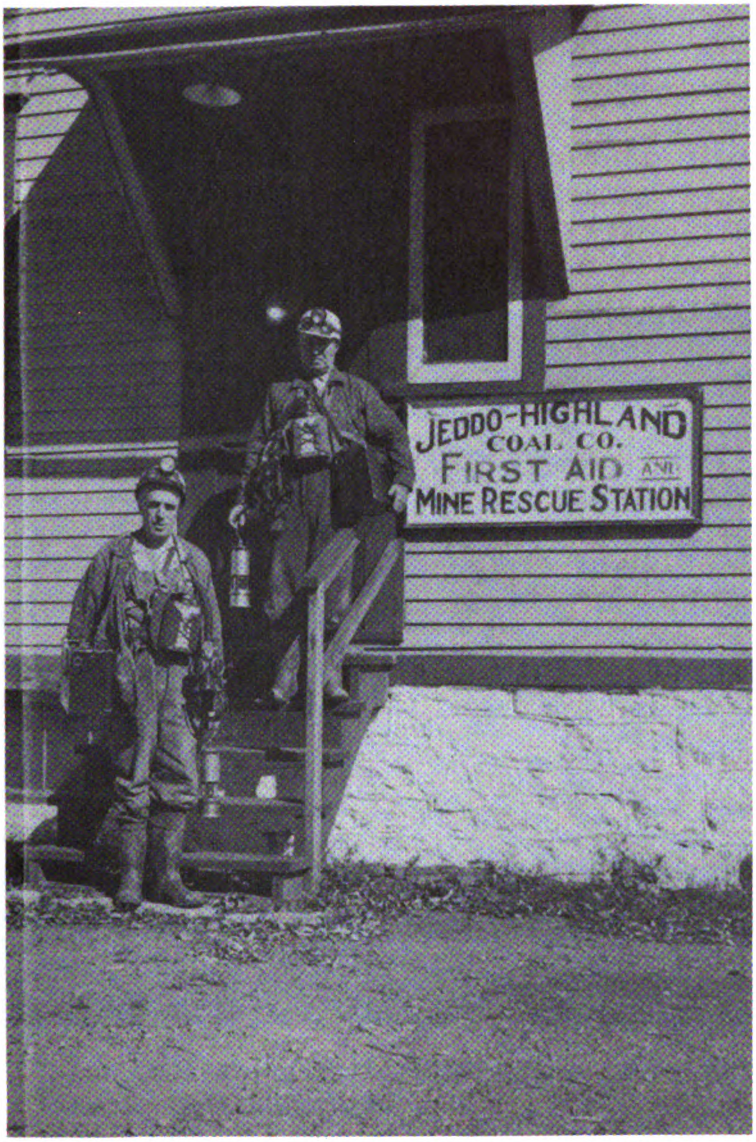

Figure 13. - Inspectors travel in pairs when making inspections. They wear safety hats, safety footwear, and have goggles. Each carries a permissible flame safety lamp, universal-type gas mask, and a carbon monoxide detector.

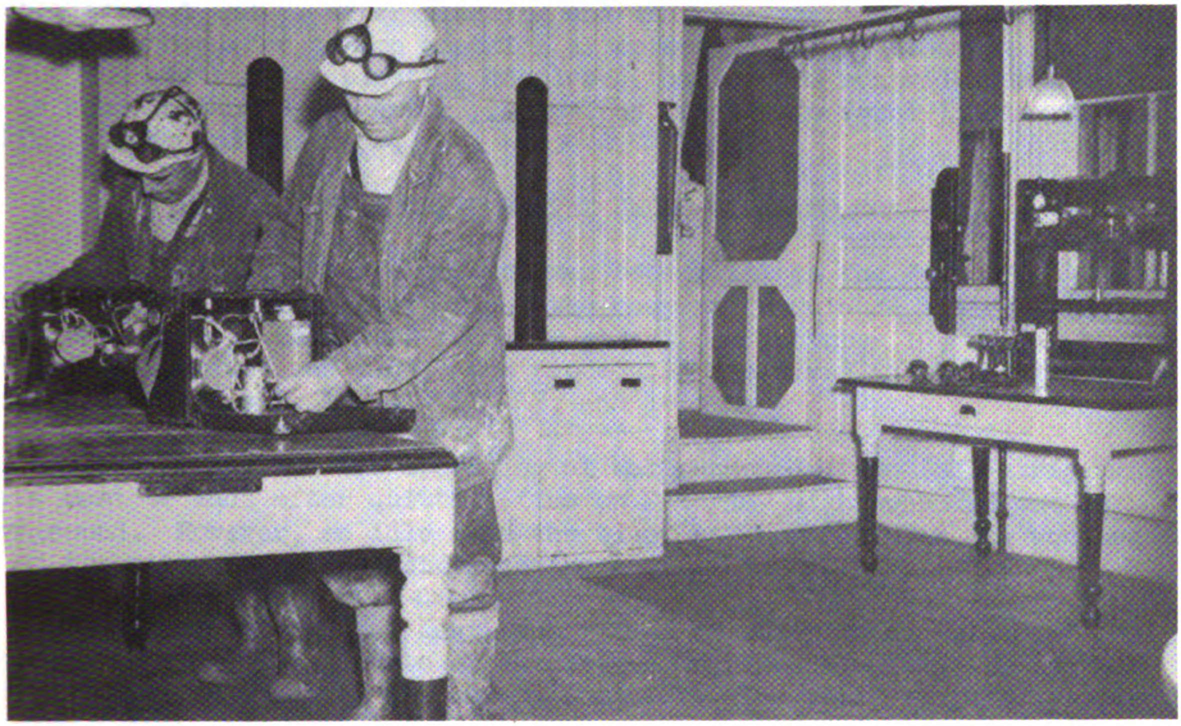

Figure 14. - After completing their inspection, inspectors clean and service their equipment.

To determine the "drift" of the smoke and noxious gases after blasting, photographs were taken at two strip pits at the time of blasting and immediately thereafter and are shown in figures 4, 5, 6, and 7.

When a large blast is fired near underground mine openings, the gases therefrom may enter the mine and, in many instances when no opening is exposed, are forced through crevices by the violence of the blast, as shown in figure 8. Records of the Jeddo-Highland Coal Co. show that as many as 14 hours have elapsed before carbon monoxide was discovered in the underground workings after blasting at a strip mine. Records of some findings are given in tables 1, 1A, 2, and 2A.

These tables reveal the conditions in two underground mines, designated as collieries 1 and 2, after blasting and indicate the importance of making tests underground for carbon monoxide after each blast in adjacent strip mines. Most of the tests after blasting disclosed that carbon monoxide was not present, but in some instances dangerous proportions of it were found in atmospheres of working places and gangways.

PRECAUTIONS ADOPTED BY THE JEDDO-HIGHLAND COAL CO.

In August 1943, after eight workmen became ill in the Jeddo No. 4 mine by gases from blasting in a strip mine, the company formulated their present safety procedures, which were put into effect on September 19, 1943, when the next stripping blast was made. The procedures are given in the following outline and by figures 9, 10, 11, 12, 13, and 14.

(a) When the mines are operating at maximum production, all strip-mine blasts must be made after quitting time on Saturday night when no one is underground. However, on idle days the blast may be made when all workmen are out of the mine after the last preceding shift.

(b) The safety engineer must be notified of the time and place of the intended blast and the amounts of explosives to be used. This information must be posted on a map by the safety engineer. The colliery superintendent and mine foreman are notified of the time of the intended blast, and it is their responsibility to see that all men are out of the mine.

(c) After making a study of the surface and underground mine maps, the safety inspectors are instructed to proceed to the underground mine. At least 10 hours must elapse before the inspectors start their examinations of the underground workings.

(d) The safety inspectors examine their equipment, such as safety lamps, carbon monoxide detectors, universal-type gas masks, and cap lamps.

(e) Traveling in pairs, the inspectors examine all working places, gangways, and adjacent places and make records of the conditions observed in each place; the records show the date of inspection, time of entering the mine, temperature, state of air flow, percentage of carbon monoxide found, and time when each place was inspected. Tables 1, 1A, 2, and 2A are records made during an actual inspection.

TABLE 1. - Report of inspection at No. 1 colliery after a stripping blast on May 24, 1947, at 10:00 P.M.

Location on Surface: Between sections 82 and 86
and 3+50 to 4+50

40 percent ammonia dynamite
Amount of Explosives Used: 27,000 pounds

Date of inspection	Starting time of inspection	Temperature reading on surface, degrees	Place inspected	Ventilation, airflow	Percent of carbon monoxide found, time	Mine temperature, degrees	Carbon monoxide cleared, date and time
May 25, 1947	7:00 P.M.	68	1st level E. Wharton Gwy.	Good	None - 7:05 P.M.	62	OK
May 25, 1947	7:00 P.M.	68	3d level E. Wharton Gwy.	Good	0.075 - 7:10 P.M.	52	5/26/47 - 4:45 A.M.
May 25, 1947	7:00 P.M.	68	East and West Mammoth Gwys.	Good	0.05 - 8:10 P.M.	52	5/26/47 - 4:30 A.M.
May 25, 1947	7:00 P.M.	68	Tunnel No. 17	Good	0.075 - 10:00 P.M.	52	5/26/47 - 5:10 A.M.

Note: A heavy rainstorm occurred on the surface and at about 9:30 P.M. the water started entering the mine and at 10:05 P.M. the inspection was stopped. A reinspection of the workings was started at 4:00 A.M. on May 26, 1947 and was completed at 11:00 A.M. All of the tests were negative.

TABLE 1A. - Report of inspection at No. 1 colliery after a stripping blast on July 26, 1947, at 10:00 P.M.

Location on Surface: Between sections 90 to 94
and 4+0 to 5+50

27,000 pounds Titan "B". 6,000 pounds Gelomite 1
Amount of Explosives Used: Total - 33,000 pounds

Date of inspection	Starting time of inspection	Temperature reading on surface, degrees	Place inspected	Ventilation, airflow	Percent of carbon monoxide found, time	Mine temperature, degrees	Carbon monoxide cleared, date and time
July 27, 1947	6:55 P.M.	80	1st level E. Wharton Gwy.	Fair	None - 7:00 P.M.	74	OK
July 27, 1947	6:55 P.M.	80	3d level E. Wharton Gwy.	Good	None - 7:05 P.M.	60	OK
July 27, 1947	6:55 P.M.	80	East and West Mammoth Gwys.	Good	None - 7:12 P.M.	55	OK
July 27, 1947	6:55 P.M.	80	Tunnel No. 17	Fair	None - 7:35 P.M.	54	OK
July 27, 1947	6:55 P.M.	80	Tunnel No. 27	Good	None - 7:40 P.M.	52	OK
July 27, 1947	6:55 P.M.	80	East and West Gamma Gwys.	Good	None - 8:00 P.M.	52	OK
July 27, 1947	6:55 P.M.	80	Rockholes Nos. 50-51 Wharton vein	Good	None - 8:05 P.M.	52	OK

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TABLE 2. - Report of inspection at No. 2 colliery after a stripping blast on April 29, 1945, at 7:45 A.M.

Location on Surface: Between sections 45 and 50

40 percent ammonia dynamite
Amount of Explosives Used: 90,000 pounds

Date of inspection	Starting time of inspection	Temperature reading on surface, degrees	Place inspected	Ventilation, airflow	Percent of carbon monoxide found, time	Mine temperature, degrees	Carbon monoxide cleared, date and time
April 29, 1945	7:00 P.M.	50	Manslope	Intake Good	None - 7:10 P.M.	-	OK
April 29, 1945	7:00 P.M.	50	No. 19 Tunnel	Good	None - 7:30 P.M.	48	OK
April 29, 1945	7:00 P.M.	50	Skidmore Gangway	Good	None - 7:45 P.M.	48	OK
April 29, 1945	7:00 P.M.	50	Rock Gangway	Fair	0.08 - 8:15 P.M.	48	5/2/45 - 2:00 P.M.
April 29, 1945	7:00 P.M.	50	Rock Gangway	Fair	0.10 - 8:50 P.M.	48	5/2/45 - 2:00 P.M.
April 29, 1945	7:00 P.M.	50	Rock Gangway	Fair	0.08 - 11:05 P.M.	47	5/2/45 - 2:00 P.M.
April 30, 1945	4/29/45 7:00 P.M.	49	Rock Gangway	Fair	0.05 - 7:57 A.M.	47	5/2/45 - 2:00 P.M.
April 30, 1945	do.	49	Rock Gangway	Fair	0.14 - 8:57 A.M.	47	5/2/45 - 2:00 P.M.
April 30, 1945	do.	49	Rock Gangway	Fair	0.09 - 2:10 P.M.	47	5/2/45 - 2:00 P.M.
April 30, 1945	do.	49	Rock Gangway	Fair	0.05 - 3:20 P.M.	47	5/2/45 - 2:00 P.M.
May 2, 1945	do.	50	A new fan was installed underground and a brattice was erected; at 6:15 A.M. the fan was started.				
May 2, 1945	do.	50	Rock Gangway	Good	None - 2:00 P.M.	48	5/2/45 - 2:00 P.M. cleared
May 3, 1945	do.	50	Complete mine reinspected	Good	None	48	OK
May 3, 1945	do.		Inspection completed May 3 - 11:30 A.M. The mine can now resume operation.				

TABLE 2A. - Report of inspection at No. 2 colliery after a stripping blast on October 7, 1945, at 9:00 A.M.

Location on Surface: Between sections 50 and 55

40 percent ammonia dynamite
Amount of Explosives Used: 60,000 pounds

Date of inspection	Starting time of inspection	Temperature reading on surface, degrees	Place inspected	Ventilation, airflow	Percent of carbon monoxide found, time	Mine temperature, degrees	Carbon monoxide cleared, date and time
October 7, 1945	6:45 P.M.	52	Manslope	Return Good	None - 6:50 P.M.	-	OK
October 7, 1945	6:45 P.M.	52	No. 19 Tunnel	Good	None - 8:50 P.M.	50	OK
October 7, 1945	6:45 P.M.	52	Skidmore Gangway	Good	None - 7:35 P.M.	53	OK
October 7, 1945	6:45 P.M.	52	Rock Gangway	Static	None - 8:00 P.M.	52	OK
October 7, 1945	6:45 P.M.	52	East Orchard Gwy.	Good	None - 8:15 P.M.	54	OK
October 7, 1945	6:45 P.M.	52	West Orchard Gwy.	Good	None - 8:05 P.M.	54	OK
October 7, 1945	6:45 P.M.	52	East Primrose Gwy.	Good	None - 8:30 P.M.	54	OK
October 7, 1945	6:45 P.M.	52	West Primrose Gwy.	Good	None - 8:45 P.M.	54	OK
October 7, 1945	6:45 P.M.	52	Holmes Tunnel	Good	None - 7:45 P.M.	54	OK

(f) Only the safety inspectors are permitted in the mine during inspection. If the tests reveal the presence of carbon monoxide, workmen are not permitted to enter the mine until the carbon monoxide is removed, except that workmen properly equipped with respiratory-protective apparatus may be permitted to enter the mine under the supervision of the safety engineer to assist in improving the ventilation.

(g) A crew of safety inspectors (at least two) must be present until all hazards from carbon monoxide have been removed.

(h) The inspectors return to their headquarters after the inspection and report their findings. If the atmosphere is uncontaminated, the mine may resume normal operations.

(i) The inspectors clean and service their equipment for the next inspection.

CONCLUSIONS

Record of the hazards found and of the procedures followed by the supervisory personnel of the Jeddo-Highland Coal Co. have proved of great value in protecting the lives of workmen in underground mines against noxious gases originating from blasting in adjacent strip mines. Precautionary measures taken by these officials for protecting underground workmen against such hazards should be of inestimable value to others operating under similar conditions.